BBC RD 1977/43

BBC

RESEARCH DEPARTMENT

1974
THE QUEEN'S AWARD
TO INDUSTRY

REPORT

CEEFAX: spectrum-shaping filter

M.J. Kallaway, M.A.

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION November 1977

BBC RD 1977/43
UDC 621.397:
621.372.54

CEEFAX: SPECTRUM-SHAPING FILTER

M.J. Kallaway, M.A.

Summary

The Report describes a simple lumped-element spectrum-shaping filter for CEEFAX data signals. Details are given on how to construct and align the filter to give the best performance.

The Report concludes that the practical filter has a performance very close to the ideal.

Issued under the authority of

G D Monteath

Head of Research Department

Research Department, Engineering Division,
BRITISH BROADCASTING CORPORATION

November 1977
(EL-136)

CEEFAX: SPECTRUM-SHAPING FILTER

Section Title Page

Summary . . . . Title Page

1. Introduction 1

2. Pulse-shape 1

3. The filter 2

4. Construction and alignment of the filter 2

5. Performance of practical filter 2

6. Conclusions 3

7. References 3

CEEFAX: SPECTRUM-SHAPING FILTER

M.J. Kallaway, M.A.

1. Introduction

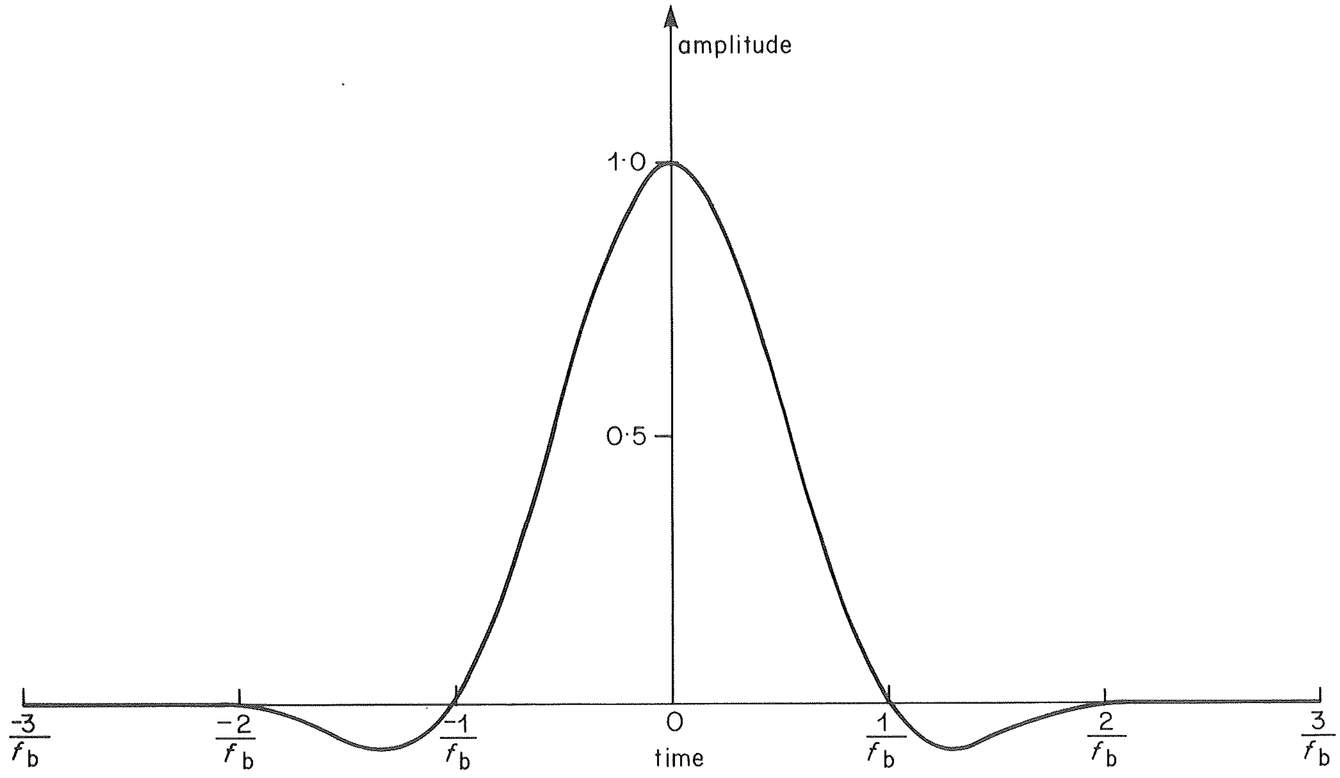
An earlier BBC Report[1] described an optimum pulse-shape for teletext signals. This was aimed at maximising the CEEFAX service areas and the average improvement in received data eye-height, compared to that obtained with the original sine-squared pulse-shape, was expected to be about 5%.

In this Report, a simple lumped-element filter is described for use in generating CEEFAX signals with the new shape. Construction and alignment details are also given.

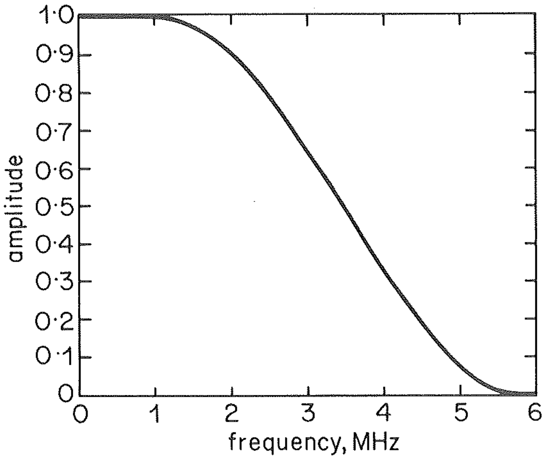
2. Pulse-shape

The new pulse-shape is shown in Fig. 1(*a*) and its spectrum, which has a 70% cosine roll-off,[2] is shown in Fig. 1(*b*). As can be seen, the pulse has a single peak and has zeroes at spacings from the peak which are multiples of the bit-period. Hence, in theory, the pulse-shape can give 100% eye-height.

It should be noted that the theoretical spectrum of the pulse extends slightly beyond the nominal video bandwidth of 5·5 MHz for System I television and 5 MHz for



(*a*)



(*b*)

Fig. 1 - Shape and spectrum of new pulse

(*a*) pulse-shape fb = 6·9375 MHz for CEEFAX (*b*) pulse-spectrum

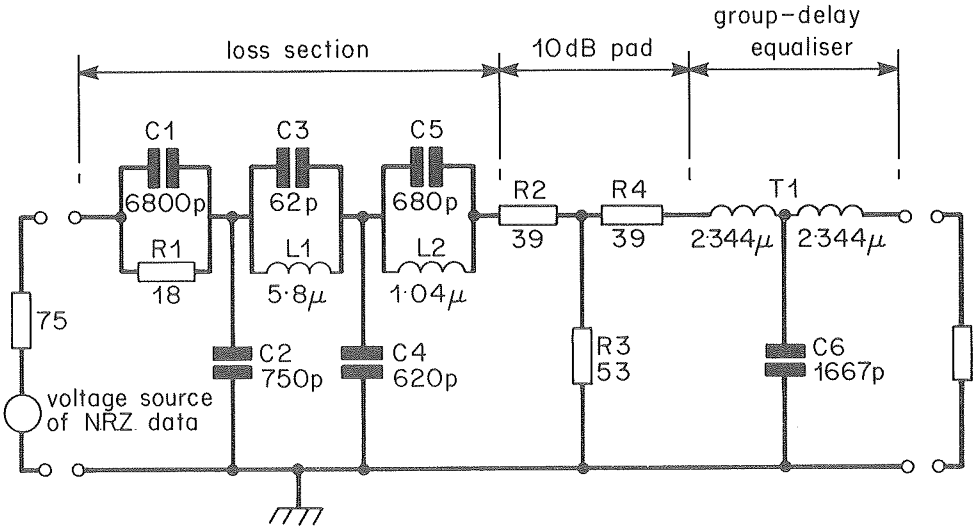


Fig. 2 - Circuit of practical filter

Systems B and G television. In practice, the pulse-spectrum may be limited by an additional low-pass filter so that it will fit into the video bandwidth of any of the three television systems; this truncation causes a loss of eye-height of about 6% in the case of the 5 MHz Systems B and G.

3. The filter

The filter which is intended to be fed with rectangular pulses of non-return-to-zero (NRZ) CEEFAX data, was designed using iterative computer programs.* To obtain the correct amplitude response, the 70% cosine roll-off spectrum of Fig. 1(*b*) was divided by the spectrum of a rectangular pulse of 144 ns duration (CEEFAX bit-period). The group-delay should of course be constant over the passband.

The practical filter is formed in two parts. There is a loss section to give the correct amplitude-response, followed by an equaliser which compensates for the group-delay response of the loss section. A 10 dB attenuator pad is inserted between the two sections to ensure correct matching of the loss section.

The circuit diagram of the filter is shown in Fig. 2; as can be seen it is relatively simple, using only 14 components overall. The filter is designed to be fed from a 75-ohm source into a 75-ohm load.

4. Construction and alignment of the filter

In order to obtain the best performance from the filter, it must be constructed and aligned with care. Components that are stable with time and temperature should be used.

All the capacitors shown in Fig. 2 should be selected to be within 1% of the values shown and all the resistors to within 2% of the values shown. In addition, all the coils should be constructed so that they have Q-factors, measured at 5 MHz, of about 100. This value of Q was included in the iterative program used for designing the filter. The transformer T1 should be bifilar wound so as to ensure very close coupling between the two halves.

Transformer T1 should be adjusted prior to being fitted so that the inductance of each half is within 1% of the value shown. The loss section has two notches in its response, one at 8·393 MHz, determined by the parallel resonance of L1 and C3, and the other at 5·985 MHz determined by the parallel resonance of L2 and C5. The inductors L1 and L2 should be adjusted, in situ, so that there are maxima of attenuation at the respective notch frequencies.

5. Performance of practical filter

The amplitude response of the practical filter was measured and is shown on a linear amplitude scale in Fig. 3

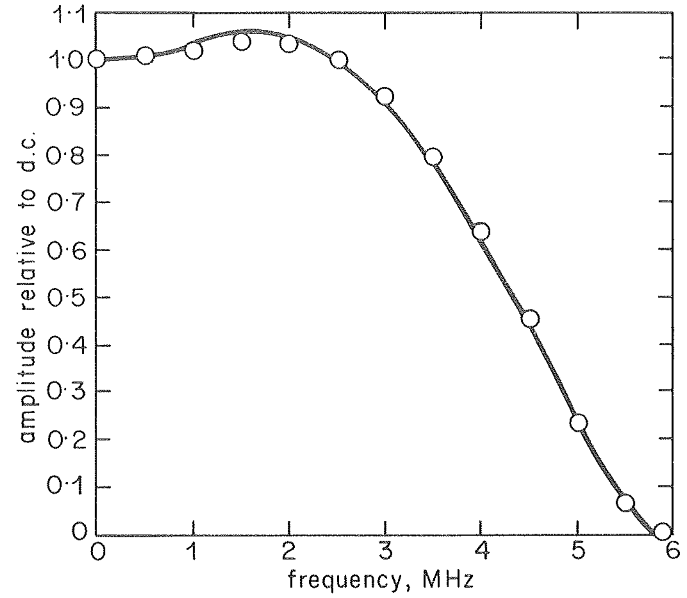


Fig. 3 - Amplitude response of practical filter; linear scale

——— ideal response O measured values

---

[*] Computer work done by D.C. Broughton, BBC Designs Department.

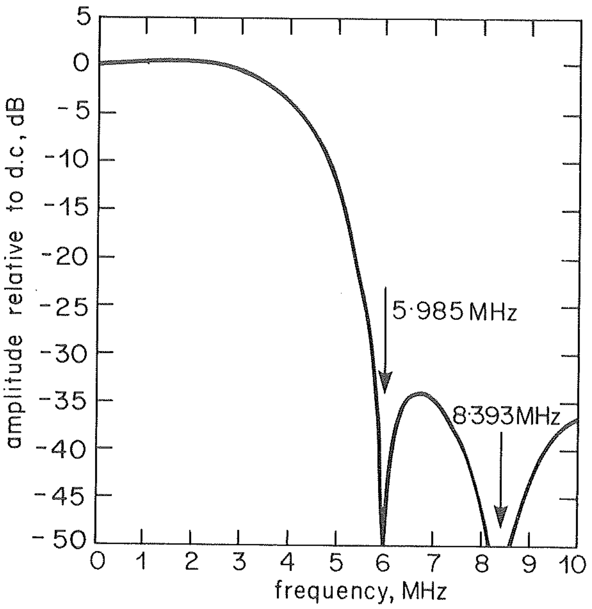


Fig. 4 - Measured amplitude response of practical filter, logarithmic scale

and on a logarithmic scale in Fig. 4. Fig. 3 allows a comparison to be made between the response of the practical filter and the theoretical response shown in Fig. 1. As can be seen, the practical filter has very nearly the ideal response, the largest error being a 2% departure in the vicinity of 1·5 MHz. Fig. 4 shows that, beyond 6 MHz, the filter has more than about 35 dB attenuation relative to low frequencies and the two notches are clearly visible. At low frequencies the insertion loss of the filter including the attenuator pad is 11 dB.

The group-delay response of the filter, with and without the group-delay equaliser, is shown in Fig. 5. It will be seen that, with the equaliser included, the group-delay response is virtually constant over the important part of the pass-band up to 4 MHz.

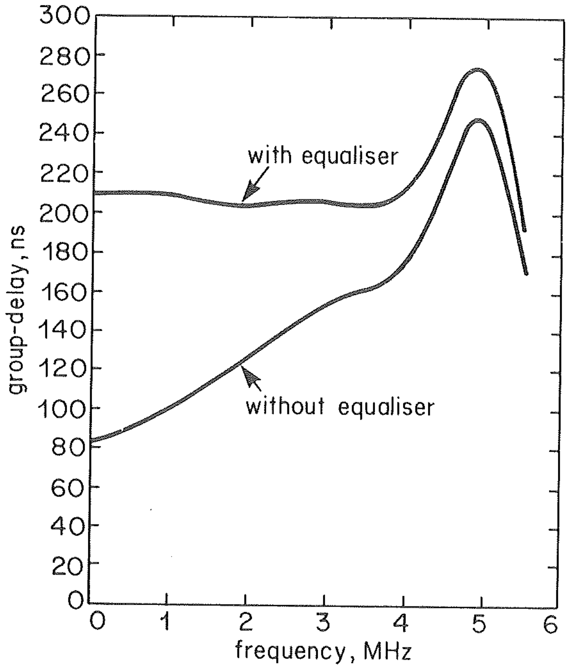


Fig. 5 - Group-delay response of practical filter

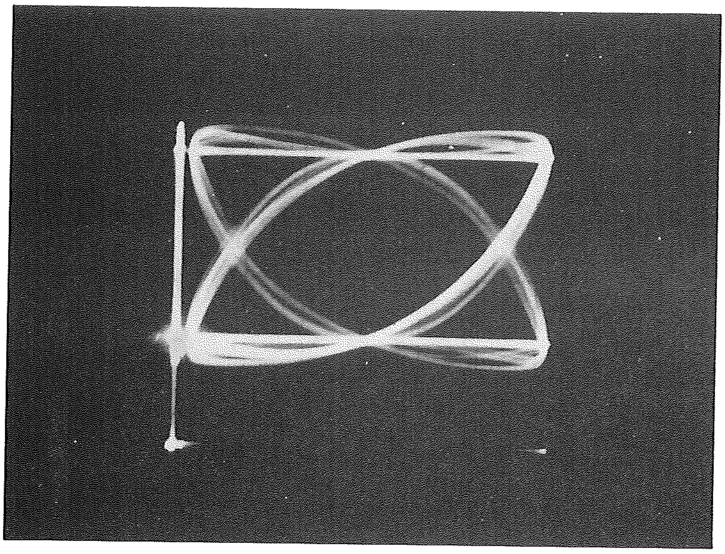


Fig. 6 - Data eye-pattern produced at the output of the filter

The eye-pattern produced at the output of the filter is shown in Fig. 6 and the measured eye-height was about 95%. This pattern was produced on an oscilloscope using a sinusoidal horizontal sweep at one quarter of the bit-rate frequency, with the data signal applied to the vertical input. Four bit-periods are displayed during each horizontal cycle, two centrally (during forward and return sweeps) and one at each side. The data source was a CEEFAX Test Pages Generator.[3]

The NRZ data signal feeding the shaping filter should have rise and fall times of less than 10 ns.

6. Conclusions

A practical filter for producing CEEFAX data signals with optimum pulse-shape has been described. The filter is relatively simple to construct and align and uses only a few components.

The performance of the practical filter is close to the ideal. The measured data eye-height at the output of the filter was about 95%.

7. References

1. KALLAWAY, M.J. *and* MAHADEVA, W.A. 1977. CEEFAX: optimum transmitted pulse-shape. BBC Research Department Report No. 1977/15.

2. BENNETT, W.R. *and* DAVEY, J.R. 1965. Data transmission. McGraw-Hill, 1965.

3. CROLL, M.G. *and* WRIGHT, D.T. 1977. CEEFAX: field trials at v.h.f. System B – Bavaria, April 1975. BBC Research Department Report No. 1977/18.

Printed by BBC RESEARCH DEPARTMENT, Kingswood Warren, Tadworth, Surrey, KT20 6NP